

Impact of Filtration on Grey Water Quality: A Comprehensive Analysis of Christian Hospital Taxila's Grey Water before and after Treatment

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Grey water, defined as wastewater excluding toilet effluents, contains varying levels of contaminants and necessitates precise reuse strategies. This study focuses on the treatment of grey water sources with relatively lower levels of contaminants, specifically excluding those from toilets which contribute the majority of harmful substances such as chemicals, body lipids, and oils. The study evaluated the physical, chemical, and microbiological parameters of household grey water, including pH, conductivity, turbidity, and the presence of elements such as calcium, magnesium, and potassium, as well as contaminants like nitrates and sulfates. The treatment system employed consisted of multiple filtration stages using sand, coconut husk, pebbles, activated charcoal, limestone, and gravel, complemented by reverse osmosis. Results indicated significant improvements post-treatment: normalization of pH, reduced conductivity, elimination of color, and substantial reductions in major contaminants. Notably, the system achieved 100% removal of *E. coli*, total coliforms, and fecal coliforms. The findings underscore the effectiveness of greywater treatment in reducing water toxicity and enhancing its suitability for various applications, thereby contributing to pollution reduction and resource conservation. Such recycling initiatives can significantly address water scarcity issues and encourage sustainable water resource management.

Keywords: Grey water composition, grey water treatment, domestic grey water, recycling, water treatment technologies.

INTRODUCTION

Agriculture crop production is the backbone to meet the food demand worldwide. However, the food demand exerts pressure on freshwater resources for agriculture irrigation purposes. The country's water table has gone down by more than 7 m, and that's why 150 million Pakistanis cannot meet their need for food due to the shortage of irrigated water available for crop production (Kahlow *et al.*, 2007). The primary issue was a decrease in water availability from 5600 m³ in 1947 to 1000 m³ in 2004. The present need is to identify and adopt measures to find the cheapest irrigation source and minimize the pressure on freshwater resources (Kahlow *et al.*, 2007). The ever-increasing global population, as well as the ever-increasing per capita water consumption, necessitates better and more logical management of water resources need to be focused. In addition, alternate irrigation sources may be used to compensate for the current water

shortage (Asano and Levine., 1996). In arid regions throughout the world, water scarcity is a major issue for crop production. For irrigation purposes, wastewater can be used in those areas where water is scarce (Shuval, 1990). The use of greywater for agricultural purposes can contribute to water conservation, the resilience of family farming food systems, and food security, especially in regions with higher water deficits. For agricultural purposes, greywater reuse can also contribute to increasing the crop production and resilience of family farming food systems, especially in higher water deficit regions. However, the social acceptance of this practice has been poorly evaluated systematically and hinders the implementation due to the resulting uncertainty among decision-makers and other stakeholders in the management of alternative sources of water in agriculture (Silva *et al.*, 2023). Governments and water management organizations are increasingly focused on the challenges of water security, especially in developing countries where water scarcity is

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more acute. To mitigate water usage, there has been a growing emphasis on raising awareness, as well as developing infrastructure for rainwater harvesting and grey water treatment facilities (Yasin *et al.*, 2017). The reuse of grey water is becoming an essential strategy for managing water demand and providing for non-potable household and commercial needs. Additionally, several factors have elevated the economics of wastewater management and treatment (Taher, 2019). These factors include growing challenges in wastewater management in both developed and developing countries, increased scarce and overextended freshwater sources, human activities causing pollution of freshwater sources, and unregulated wastewater discharge into rivers and oceans which poses significant health risks and ecological damage. Many developing nations have inadequate or insufficient wastewater treatment systems.

Grey water, defined as household wastewater excluding toilet effluents, accounts for approximately 50-80% of total domestic water use, making it a substantial potential source for on-site water reuse (Talpur, 2020). Recent advancements in cost-effective grey water treatment technologies have highlighted significant opportunities for the reclamation and reuse of grey water in underprivileged regions for non-potable purposes such as gardening, irrigation, and toilet flushing (Spychala *et al.*, 2019). Greywater, which comprises 50-80% of total household wastewater, originates from sources like showers, hand-washing basins, and laundry machines, but excludes toilet waste and food waste from garbage grinders, classified as blackwater (Wilderer, 2004). This wastewater typically contains about 18-22% potassium (K), 20-32% phosphorus (P), and 9-14% nitrogen (N). With basic treatment, greywater can be effectively reused. Once treated, greywater can be repurposed for various non-potable uses including indoor applications such as toilet flushing, as well as for outdoor uses like irrigation and vehicle washing (De-Couto *et al.*, 2013). For agricultural reuse, treated greywater must meet specific health and environmental standards to ensure safety and sustainability (Rodda *et al.*, 2011).

The quality of grey water varies based on its source, necessitating a strategic focus on the least contaminated sources. Studies indicate that 50–60% of grey water originates from bathroom activities, containing high levels of contaminants from body fats, oils, and various chemical products found in toiletries such as toothpaste, hair dye, soap, and shampoo, some of which also show signs of fecal contamination (Shaikh *et al.*, 2015). Laundry activities contribute about 4% of grey water, while all washing activities together constitute approximately 25–30% of total grey water output (Samayamanthula *et al.*, 2019). Kitchen grey water, which accounts for about 10% of the total, is considered the most contaminated source, laden with food particles, oils, and greases and is sometimes excluded from the grey water category, necessitating specific treatment technologies before reuse (Rozin, 2015).

Greywater recycling is becoming increasingly viable as a practical method for conserving water, especially in urban residential structures. Greywater, originating from areas such as bathrooms, kitchens, and laundry machines, typically demands less treatment compared to residential wastewater due to its lower pollutant content. Greywater can be classified into two primary categories according to its nutritional composition: bathroom and laundry water, which have insufficient amounts of nitrogen and phosphorus, and kitchen greywater, which usually has a well-balanced N:P ratio and is easily broken down by biological processes.

Physical treatment systems, such as sand and activated carbon filtration, are frequently employed but typically necessitate the employment of additional procedures, such as disinfection, to achieve optimal efficacy. Research has yielded inconclusive findings about the effectiveness of these systems. For example, Gual *et al.* (2008) saw slight decreases in TSS and COD, but Dalahmeh *et al.* (2012) and Brewer *et al.* (2001) discovered more substantial enhancements in nitrogen reduction and microbial load reduction, respectively. Ultrafiltration and nano-filtration have different levels of effectiveness in lowering organic loads and turbidity, with nano-filtration often yielding superior outcomes (Ramona *et al.*, 2004; Šostar-Turk *et al.*, 2005).

Chemical treatment systems, such as coagulation and electrocoagulation, are highly successful in lowering the amount of organic matter and presence of microorganisms in greywater. Lin *et al.* (2005) showed that electrocoagulation is highly successful in eliminating *E. coli* and reducing organic debris. The utilization of coagulation in conjunction with ion-exchange resins demonstrated favorable outcomes in decreasing BOD₅, turbidity, and nutrients to comply with reuse guidelines. Biological treatment systems, especially those utilizing fixed biomass, are regarded as very efficient for large-scale applications. These systems have the ability to greatly decrease the presence of organic molecules, nutrients, and microbiological content in greywater. For instance, Sun *et al.* (2020) and Lamine *et al.* (2007) documented significant decreases in BOD₅, COD, and turbidity. Membrane bioreactors (MBR) are renowned for their exceptional efficacy and capacity to manage variations in greywater quality, resulting in a significant reduction in COD, BOD₅, and surfactants (Lin *et al.*, 2005).

The selection of treatment is contingent upon the intended application of the processed greywater, local regulatory requirements, and the unique attributes of the greywater in question. According to Diaper *et al.* (2001) and Kariuki *et al.* (2012), it is advised to use treated greywater for non-potable activities like toilet flushing and irrigation, depending on the specific treatment process employed. Advanced treatment methods, including as membrane filtration and biological filters, not only assist in meeting the regulatory requirements for reuse but also seamlessly blend into the ecosystem, promoting biodiversity (Gross *et al.*, 2007; Dallas *et al.*,



2004). To summarize, efficient greywater treatment depends on utilizing a blend of physical, chemical, and biological procedures that are customized to the unique characteristics of the greywater and the desired purpose of its subsequent usage. This approach guarantees the ecological integrity and long-term viability of greywater recycling practices.

MATERIALS AND METHODS

For physicochemical and microbiological analysis, a sample of domestic grey water was collected. Physicochemical parameters including color, electrical conductivity, pH, and turbidity, alkalinity as CaCO₃, bicarbonates, calcium, carbonates, chlorides, total hardness, magnesium, potassium, sodium, sulphate, and nitrate were carried out. For the determination of physicochemical and microbiological characteristics, standard procedures are utilized (Spsychala *et al.*, 2019).

Grey Water Treatment Unit Specifications

Collection tank: Before the first stage of treatment, the water is first held in this tank. Around 20,000 litres of water can be stored in the tank at one time.

Filtration tank: The water is finally purified by letting it run through a bed of sand, coconut husk, pebbles, activated charcoal, coconut husk, limestone and large-size gravel. The remaining suspended stuff is trapped in the sand, coconut husk, and activated charcoal bed as water filters through the filtration medium. Water is filtered via a filtration medium bed by flowing on top of it, through it, and then collecting at

the bottom in drains. To filter the water, it goes through filter media.

Storage tank: The water after filtration is collected in the storage tank. This tank holds the water for further filtration through reverse osmosis plant.

Reverse osmosis plant: When pressure pushes water through a semipermeable membrane, reverse osmosis eliminates pollutants from unfiltered water, or feed water. To produce clean drinking water, water flows from the more concentrated side of the RO membrane which has more impurities to the less concentrated side which has less contaminant.

RESULTS

Grey Water Physical, Chemical, and Biological Parameters results from a sample of grey water included the following. High concentrations of the following parameters were found: color, electrical conductivity, pH, and turbidity, alkalinity as CaCO₃, bicarbonates, calcium, carbonates, chlorides, total hardness, magnesium, potassium, sodium, sulphate, and nitrate. The post-treatment outcome of the planned unit's grey water was within acceptable bounds. E. coli, total coliforms, and faecal coliforms had 100% removal efficiency.

Physical and Aesthetic Parameters: The result of our study showed in Table 1 that there is a significant difference between the pre-filtration and post-filtration assessment. The result indicated that in pre-filtration condition the color of water was muddy with electrical conductivity 1752, (pH=basic) and turbidity was 300 (turbidity=300) and after filtration water became colorless, electrical conductivity

Table 1. Physical and Aesthetic Parameters.

Sr.	Reference Methods	Water Quality Parameter	Unit	Results	
				Pre-test	Post-test
1	Sensory Evaluation	Color	-	Muddy	Colorless
2	APHA, 23rd Edition	Electrical Conductivity	(μ S/cm)	1752.00	112.00
3	APHA, 23rd Edition	pH	-	8.72	6.54
4	APHA, 23rd Edition	Turbidity	NTU	300.00	Below Detectable Limit

Table 2. Chemical Parameters.

Sr.	Reference methods	Water quality parameter	Unit	Results	
				Pre-test	Post-test
1	APHA, 23rd Edition	Alkalinity as CaCO ₃	mg/L	392	32
2	APHA, 23rd Edition	Bicarbonates	mg/L	392	32
3	APHA, 23rd Edition	Calcium	mg/L	81	13
4	APHA, 23rd Edition	Carbonate	mg/L	30	0
5	APHA, 23rd Edition	Chlorides	mg/L	58	10
6	APHA, 23rd Edition	Total Hardness	mg/L	252	42
7	APHA, 23rd Edition	Magnesium	mg/L	12	2
8	APHA, 23rd Edition	Potassium	mg/L	3.5	0.9
9	APHA, 23rd Edition	Sodium	mg/L	290	7
10	APHA, 23rd Edition	Sulphate	mg/L	225	10
11	APHA, 23rd Edition	Nitrate (N)	mg/L	39.1	0.9
12	APHA, 23rd Edition	Total dissolve solvent	mg/L	1051	62



reduced to 112, (pH=neutral) and turbidity of solution also reduced below detectable limit. All the differences in physical and aesthetic parameters in pre and post-intervention were due to the water filtration process.

Chemical Parameters: The Table 2 present pre- and post-intervention results of different chemical parameters. The results showed that pre-test results of Alkalinity as CaCO₃ Bicarbonate (pre-test =392.00) significantly decreased (post-test=32) in post-test condition. The results showed that value of Calcium in pre-test intervention (pre-test =81.00) significantly decreased after the intervention (post-test =13.00). Also, the pre-test value of chloride (58.00) was decreased (post-test =10.00) in post-intervention condition. The results showed that the value of carbonates (pre-test =30.00) was not measurable in post-test condition and pre-test total hardness value (=252.00) significantly dropped to 42 (post-test =42.00) in post-intervention condition. The results also indicated that the value of magnesium and potassium was 12 and 3.50, respectively, which significantly decreased to 2 and 0.90, respectively. Also, pre-test sulfate value was found to be 225.00 which dropped in post-test condition (post-test =7.00). The value of sodium in pre-test (290.00) was reduced after filtration (post-test =10.00). The value of nitrate (N) was 39 and value of total dissolvent solvent was 1051 in pre-test condition which dropped in post-test condition (post-test =0.90 and 62, respectively). All the differences in chemical parameters in pre- and post-intervention were due to water filtration process, as no additional intervention or manipulation was done to the water.

Microbiological Parameters: The results of the study in Table 3 indicated the pre- and post-filtration results of coliforms, fecal coliforms and E-coli. Before the filtration intervention process, coliform was 28.00, which were removed by filtration in post-test condition. The results showed that fecal coliform was 10, which was improved to zero in post-intervention. Also, the E-coli results were negative after the intervention which was 12 before the intervention. All the differences in microbiological parameters in pre- and post-intervention was due to water filtration process, as no additional intervention or manipulation was done to the water.

DISCUSSION

The findings of this study demonstrate the effectiveness of water filtration as a method to significantly improve the physical, chemical, and microbiological quality of grey water.

Grey water is known to contain contaminants that can affect its suitability for reuse, highlighting the importance of appropriate treatment strategies. The pre-filtration assessment revealed high turbidity and color, along with elevated electrical conductivity and a basic pH. Post-filtration, these parameters notably improved, with water becoming colorless, turbidity reduced below detectable limits, and electrical conductivity significantly lowered. These improvements can be attributed to the filtration process, which effectively removed suspended particles and impurities responsible for the initial turbidity and coloration.

Color, electrical conductivity, pH, and turbidity were some of the parameters tested in the study to see how well the filtration process worked. After the filtration process, the results showed that the quality of the water had significantly improved. Electrical conductivity decreased from 1752 S/cm to 112 S/cm, the water's color changed from muddy to colorless, and the turbidity fell below detectable limits. Additionally, the water's pH changed from basic to neutral. The study concluded that the filtration process alone was responsible for the improvement in the water's quality; no other actions were taken to the water. The filtration process significantly reduced the levels of calcium, magnesium, and total hardness in the water samples. The water samples' pre- and post-filtration evaluations differed significantly, according to the findings. The Alkalinity, Calcium, Carbonate, Chloride, Total Hardness, Magnesium, Potassium, Sodium, Sulfate, Nitrate, and Total Dissolve Solvent were likewise further developed altogether after the filtration intercession.

The chemical analysis demonstrated substantial reductions in various parameters post-filtration. Notably, alkalinity as CaCO₃, bicarbonates, calcium, carbonates, chlorides, total hardness, magnesium, potassium, sodium, sulphate, nitrate, and total dissolved solids exhibited significant decreases after filtration. These changes indicate the successful removal or reduction of dissolved minerals and ions during the treatment process. The filtration process was highly effective in removing microbial contaminants. E. coli, total coliforms, and fecal coliforms were completely eradicated, achieving 100% removal efficiency. This outcome is crucial for ensuring the safety and suitability of grey water for various non-potable uses.

After the filtration procedure, the concentration of coliforms, fecal coliforms, and *E-coli* significantly decreased. The coliform pre-test resulted in 28 CFU/100 ml, which were completely eliminated by filtration. Essentially, waste

Table 3. Microbiological Parameters.

Sr.	Reference Method	Water Quality Parameter	Unit	Results	
				Pre-test	Post-test
1	APHA, 23rd Edition	Total Coliforms	CFU/100 MI	28.00	Negative
2	APHA, 23rd Edition	Fecal Coliforms	CFU/100 MI	10.00	Negative
3	USEPA-1603	<i>E-coli</i>	CFU/100 MI	12.00	Negative



coliforms, which were 10 CFU/100 ml before the filtration, became negative in the post-test condition. The *E-coli* focus was 12 CFU/100 ml before the filtration, and it was totally taken out after the filtration intercession. Therefore, the successful outcomes observed in this study highlight the importance of employing suitable filtration techniques for grey water treatment. Such interventions are essential for enhancing water quality and safety, especially in scenarios where grey water reuse is considered for non-potable applications. The significant improvements in physical, chemical, and microbiological parameters underscore the efficacy of filtration as a sustainable solution for grey water management.

Conclusions: The treated grey water can be used in households other than drinking, irrigation and gardening. The results provide important information on grey water management and environmental improvement. Usage of grey water regularly reduces the need for drinking water and saves a lot of money and energy. The use of treated grey water not only reduces freshwater consumption, but also reduces wastewater discharge into the environment.

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